

(43) Date of A publication 01.11.1989

(21) Application No 8907850.5

(22) Date of filing 07.04.1989

(30) Priority data

(31) 8808261

(32) 08.04.1988

(33) GB

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(51) INT CL^a

G01B 21/08 7/10 11/06 17/02

(52) UK CL (Edition J)

G1A AA2 ABA AG16 AG7 AR7 AS10 AS4 AT1

AT26 AT3 AT8

U1S S2139 S2145

(56) Documents cited

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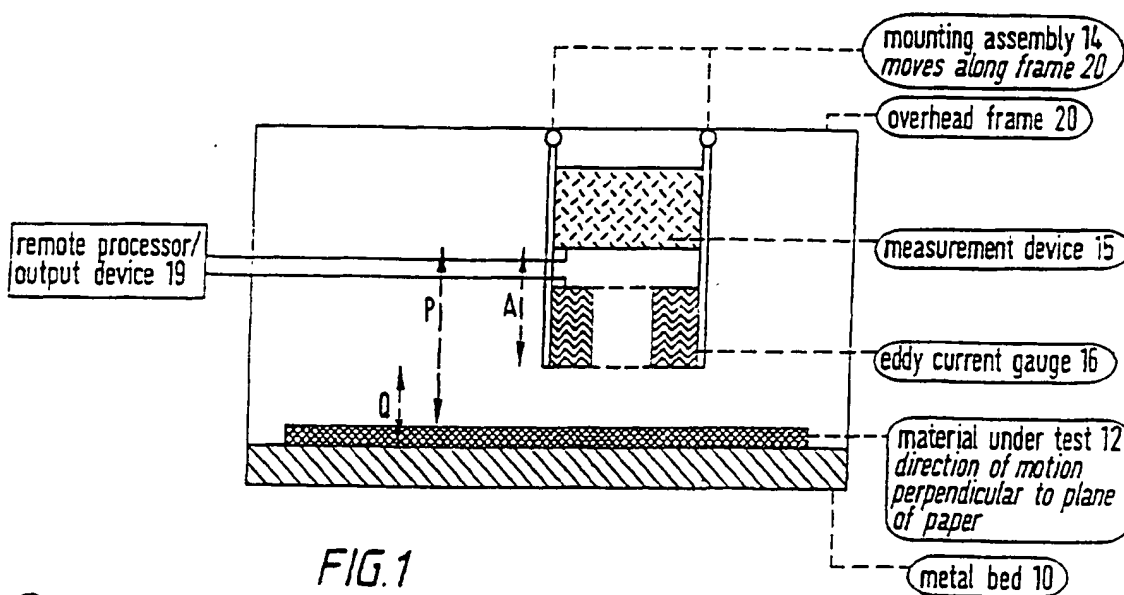
(58) Field of search

UK CL (Edition J) G1A ABA ABG

INT CL^a G01B

(54) Thickness measurement device

(57) Thickness measuring apparatus for accurately measuring the thickness of a flat object such as a sheet material. The apparatus includes a radiation type measuring device (15), e.g. a laser type device which can measure the distance to a first surface of the object and an eddy current type device (16) which can measure distance to the other surface of the object. The thickness is obtained by subtracting the two distances. The eddy current type device has an open central region so that the radiation type device can be located generally coaxially with it. This arrangement minimises errors when the apparatus is moved relative to the object.



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THICKNESS MEASUREMENT DEVICE.

5 This invention relates to thickness measuring devices. It has particular application to devices which can measure the thickness of a magnetically transparent object to a relatively high degree of accuracy, typically to within one or two microns.

10 Known techniques for measuring the thickness of an object, typically non-metallic sheet material, to a high degree of accuracy fall into one of two categories. In the first the thickness of the object is determined by measuring the absorption of radiation
15 such as beta particles transmitted through the object. The thickness of the object can be evaluated assuming that the absorption coefficient of the radiation is known for the material of the object, as well as its density.

20 The other known technique involves direct measurement of distance. In this technique, the object whose thickness is to be measured, is located on a flat bed to which a rigid overhead frame is attached. This frame carries an ultrasonic, or a laser or other
25 optical distance measuring device (hereinafter

referred to as the prime measuring device) which directs a beam of radiation towards the top surface of the object under test and senses the beam reflected back from that top surface. In this way the distance to the top surface of the object can be evaluated and knowing the distance to the bottom surface, namely the distance to the flat bed, the thickness of the object can be calculated. Other known devices permit the passage of the object between two oppositely disposed rigidly connected prime measuring devices which determine the position of the top and bottom surfaces of the material and hence the thickness of the object. Known devices require a very rigid frame in order to carry the measuring devices as distortions in the position of these devices generate errors in the calculated thickness measurement. This is because known devices rely on a knowledge of distance between two reference points in the structure of the measuring devices.

An object of the present invention is to provide a thickness measuring arrangement which does not suffer from this disadvantage.

According to the present invention there is provided a thickness measuring apparatus for measuring the thickness of an object which comprises a prime

measuring device of the type which measures distance
to one surface of an object by transmitting radiation
towards the object and sensing radiation reflected
back from that surface and a second measuring device
5 of the inductive type which is used to determine the
position of a reference point or level, said
second device having a region or zone through which
radiation from the prime device can be transmitted and
said first device being disposed generally coaxially
10 with said gauge region or zone. In one form of the
invention the reference point or level is the other
surface of the object. In this type of arrangement the
evaluation of thickness involves a subtraction step in
which a distance measured by the first device is
15 subtracted from a distance measured by the second
device so that the effects of any distortion in the
structure of the device tend to cancel each other out.

The inductive type gauge may be an eddy current
type gauge and it may be generally toroidal in form.
20 This gauge operates by virtue of the surface of the
object being in contact with metal, e.g. a metal bed
or roll.

The object may be located on a flat bed or roll
and the gauge used to measure the distance to said bed
25 or roll, the thickness calculation involving

subtraction of the distances measured by the first and second devices.

Alternatively the object may be located on supporting rollers or otherwise maintained such that a portion of the object to be measured is freely supported between spaced support points and the device may include a third measuring device of the prime type which measures distance to the other surface of the object, said third device being disposed generally coaxially with the first device, but on the opposite side of said object whereby it measures distance to the other surface of the object, and said gauge type device is used to measure distance to said third device or a point of reference on the mounting of said third device. In this arrangement the gauge is used to check for any errors which result, e.g. from movement of the third device when it is moved relative to the object to measure the thickness at various points over the object.

The first and third devices may be optical, e.g. laser type devices or ultrasonic type devices.

The invention will be described now by way of example only, with particular reference to the accompanying drawings. In the drawings:

Figure 1 is a schematic view of a thickness

measuring device in accordance with the present invention; and

Figure 2 is a view similar to Figure 1 of a modified form of the invention.

5 Referring to the drawings, a thickness measuring apparatus comprises a flat metal bed 10 having an accurately machined surface. A sheet-like object 12 formed of a material which is magnetically transparent and whose thickness is to be measured, is located on
10 this metal bed. The object to be measured may be stationary or moving. Disposed above the metal bed 10 and spaced therefrom so that the object can pass beneath it is a mounting arrangement 14 for two measuring devices. The mounting arrangement is
15 suspended from a frame 20 so that it can move along the frame. A first measuring device indicated generally at 15 is a device of the type which is arranged to transmit radiation, e.g. laser light or ultrasound, towards the object 12 and to sense
20 radiation reflected back from the upper surface of the object. The second measuring device shown at 16 is a toroidal eddy current gauge. Thus the eddy current gauge has a central region or zone which is transparent to radiation from the device 15, and the
25 device 15 is mounted generally coaxially above that

region or zone so that the radiation is transmitted substantially centrally through the aperture in the eddy current gauge. The first and second measuring devices are electrically connected to a processing
5 device 19 so that the device 19 can process output signals received from the measuring devices.

In use of the apparatus the laser device 15 transmits radiation towards the object 12 and light is reflected back from the upper surface of the object 12
10 to the laser device 15. If the object 12 is in motion, it will be moving along a direction perpendicular to the plane of the drawing. By sensing the reflected light this device measures the distance P shown on the drawing. The eddy current gauge is used to measure the
15 distance from the device to the surface of the metal bed 10. This corresponds to the lower surface of the object 12. Knowing the distance A which is a constant, it can thus be seen that the thickness of the object can be calculated by a simple arithmetic
20 operation. This operation involves subtraction of the measurements P and Q and hence, any errors arising from distortion of the frame which carried the two measuring devices 15 and 16, tend to cancel out in this subtraction process. These arithmetic operations
25 are carried out by the processor 19.

A significant feature of the arrangement is that the devices 15 and 16 are located generally coaxially so that there are substantially no errors arising from any lack of parallelism between the surface of the test bed and the measuring devices 15, 16.

Furthermore the assembly of devices 15 and 16 is mounted on the overhead frame shown at 20, so that it can be moved relative to the object 12 to measure the thickness of the object at different points across the object. The measurement technique is such that any displacement of the measuring devices 15 and 16 as a result of such movement does not affect the resulting thickness measurement because of the fact that the calculation of thickness involves subtraction of the distances P and Q.

An alternative arrangement shown in Figure 2 makes use of rollers in place of the metal bed 10. In this alternative arrangement the rollers (not shown) are spaced apart so that the object 12 can be supported between them in a manner similar to that described above, but without the metal bed. A second laser-type measuring device 26 is located below the object so that it can be used to evaluate the distance to the lower surface of the object. The second laser-type device 26 is supported on a mounting assembly 22

which can move along a frame 24. In this arrangement the eddy current gauge 16 is used to sense distance to this second measuring device. To enable this to be achieved the device 26 is provided with a metallic target 28 which acts a reference point for the eddy current gauge.

5 In the arrangement show in Figure 2 the thickness of the object is given by $(A+B) - (P+R)$, this being evaluated by the processor 19 in response to electrical signals received from the devices 15, 16
10 and 26.

CLAIMS:

5 1. A thickness measuring apparatus for measuring
the thickness of an object which comprises a prime
measuring device of the type which measures distance
to one surface of an object by transmitting radiation
towards the object and sensing radiation reflected
back from that surface and a second measuring device
10 of the inductive type which is used to determine the
position of a reference point or level, said second
device having a region or zone through which radiation
from the prime device can be transmitted and said
first device being disposed generally coaxially with
15 said gauge region or zone.

2. A thickness measuring apparatus according to
claim 1 wherein said reference point or level is the
other surface of the object.

20

3. Apparatus according to claim 1 or claim 2,
wherein the inductive type gauge comprises an eddy
current type gauge.

4. Apparatus according to claim 3, wherein the eddy current gauge is coreless and generally toroidal in form.

5 5. Apparatus according to any preceding claim,
wherein the object is arranged to be located on a flat
bed or roll and the second device is used to measure
the distance to said bed or roll, the thickness
calculation involving subtraction of the distances
10 measured by the first and second devices.

6. Apparatus according to claim 1, wherein the object
is arranged to be located on supporting rollers or
otherwise maintained such that a portion of the object
15 to be measured is freely supported between spaced
support points and the apparatus includes a third
measuring device of the prime type which measures
distance to the other surface of the object, said
third device being disposed generally coaxially with
20 the first device, but on the opposite side of said
object whereby it measures distance to the other
surface of the object, and said inductive device is
used to measure distance to said third device or a
point of reference on the mounting of said third
25 device.

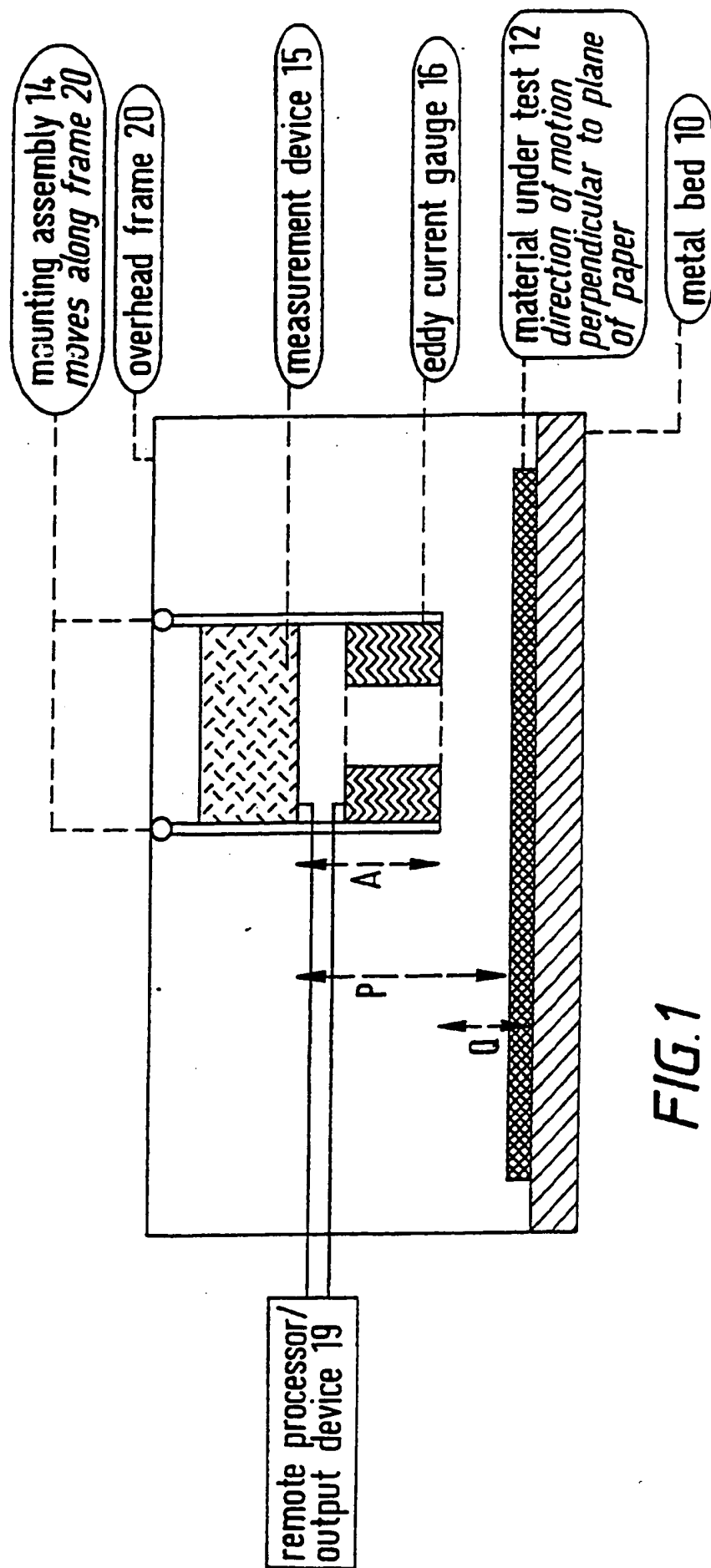
7. Apparatus according to any one of claims 1 to 6,
wherein the first device is an optical type device
such as a laser device.

5 8. Apparatus according to any one of claims 1 to 6,
wherein the first device is an ultrasonic type device.

9. Apparatus according to any one of claims 6 to 8,
wherein the third device is an optical type device
10 such as a laser device.

10. Apparatus according to any one of claims 6 to 8,
wherein the third device is an ultrasonic type device.

15 11. Thickness measuring apparatus substantially as
hereinbefore described with reference to and as shown
in the accompanying drawings.



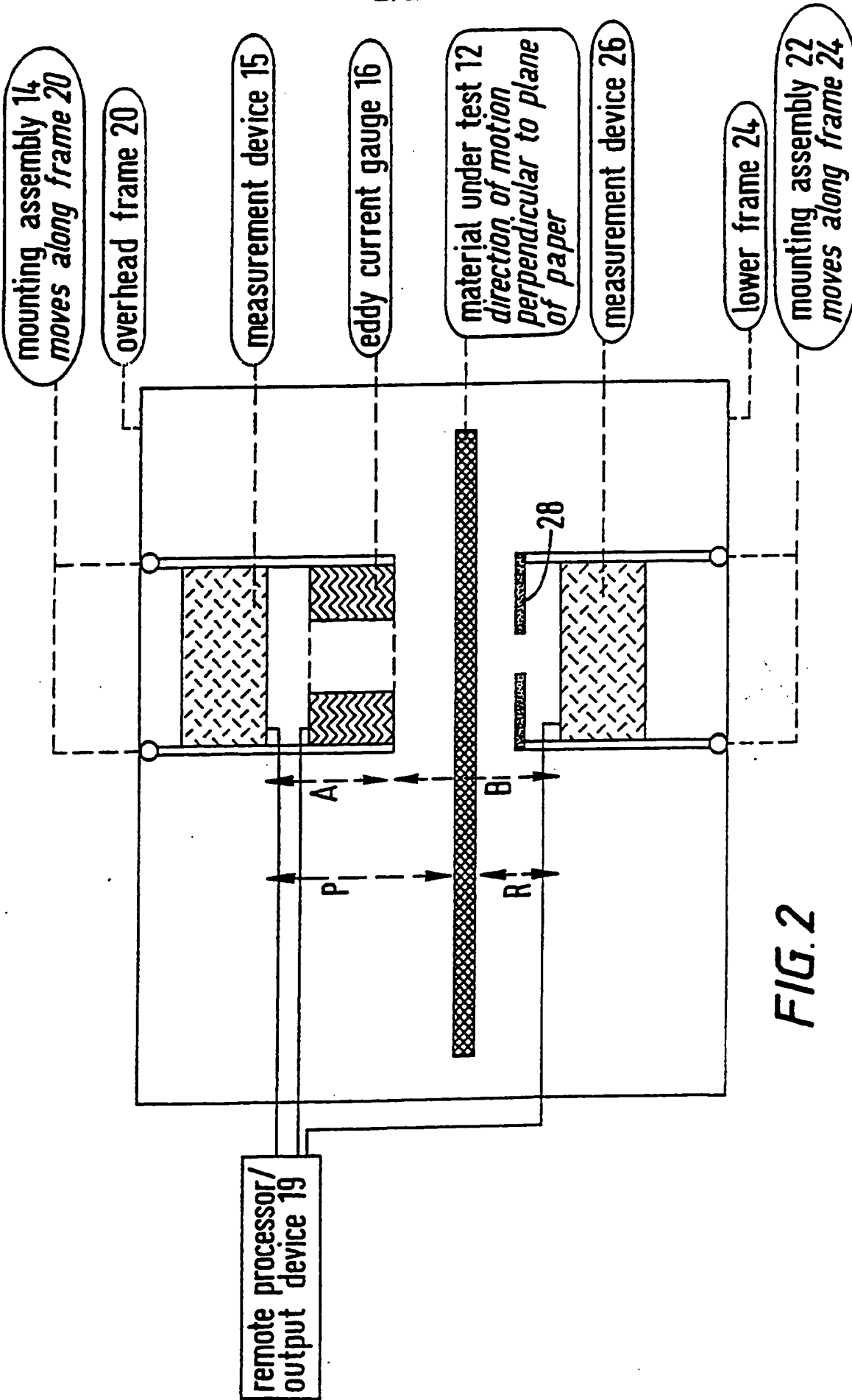


FIG. 2